APPRAISAL OF THE QUALITY OF GROUND WATER IN THE HELENA VALLEY, MONTANA

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 32-73

Prepared in cooperation with
Lewis and Clark County Commissioners and
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16. Abstracts

Analyses of ground-water samples from the Helena valley in west-central Montana show that nitrate (as nitrogen) concentrations ranged from less than 0.1 to 6.3 mg/l (milligrams per liter) and that the median value was 0.9 mg/l. Chloride concentrations ranged from 1.4 to 120 mg/l, and the median value was 8.4 mg/l. The areal distribution of nitrate indicates that the sources of nitrate are in the valley, and that areas of high nitrate concentrations coincide with areas of dense population.

Results of bacteriological analyses of 65 samples of ground water indicate that coliform bacteria were absent.

Ten water samples analyzed for trace element content had a few moderately high concentrations of arsenic, copper, lead, and zinc.

With few exceptions, ground water in the Helena valley is of good quality and mostly a calcium bicarbonate type. Despite locally high dissolved-solids content, the water is suitable for drinking, according to U.S. Public Health Service standards.

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*Ground-water movement, *Nitrates, *Septic tanks, *Sewage effluent, Nutrients, Water levels, Water quality, Heavy metals, Bacteria, Public health, Montana

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UNITED STATES DEPARTMENT OF THE INTERIOR

Rogers C. B. Morton, Secretary

GEOLOGICAL SURVEY

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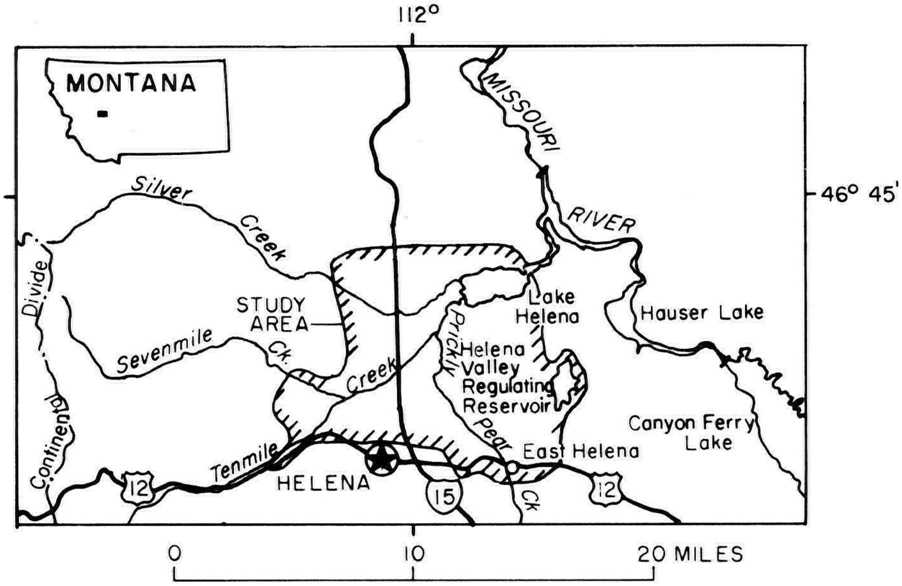

Figure 1. Study area.

Several types of contamination can result from septic-tank effluent. For example, bacteriological contamination can occur if septic-tank effluent carrying pathogens becomes mixed with ground water. Sand and gravel tend to filter micro-organisms and keep them from moving very far from their source; however, the possibility of bacteriological contamination increases where the water table is shallow, where septic systems are improperly constructed, or where conduits develop between wells and septic systems. Nitrate, ammonia, and other nitrogen compounds from septic-tank effluent can have toxic effects on man. Large amounts of nitrate in drinking water can cause nitrate poisoning in infants (U.S. Public Health Service, 1962).

Not all homes and businesses in the Helena valley have individual waste-disposal systems. Treasure State Acres (10N3W8c), Cooney Convalescent Home (10N3W18c, "County Hospital"), Fort Harrison (10N4W15), and the city of East Helena are served by sewage lagoons. Helena is served by a primary sewage treatment plant (10N3W17d), which discharges treated effluent into Prickly Pear Creek. Seepage from sewage lagoons or sewage-plant effluent contains the same nitrogen compounds as septic-tank effluent. Other sources of nitrate are accumulated animal wastes in small pastures or corrals where horses or cattle are confined, and nitrogen fertilizers applied to farm lands.

For some elements, compounds, and organisms, standards for potable water used by carriers engaged in interstate commerce have been set by the U.S. Public Health Service (1962). These standards may be used to evaluate public water supplies in the United States. The standards include limits for certain substances which, if exceeded, shall be grounds for rejection of the supplies. Limits for other substances are recommended that should not be exceeded whenever more suitable supplies are, or can be made, available at resonable cost. A copy of these standards are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402, by ordering "Public Health Service Publication No. 956". A listing of the limits for substances for which analyses are included in this report follows:

Substance	Concentrations which should not be exceeded if more suitable supplies can be made available	Concentrations which shall constitute grounds for rejection of the supply
Arsenic (As)	10 µg/l 1/	50 µg/l
Cadmium (Cd)		10 µg/l
Chromium (Cr^{+6})		50 µg/l
Chloride (Cl)	250 mg/l 2/	
Copper (Cu)	1,000 µg/l	
Fluoride (F) (approximate limit for Helena valley) 3/		1.5 mg/l
Iron (Fe)	300 µg/l	
Lead (Pb)		50 µg/l
Manganese (Mn)	50 µg/l	
Alkyl benzene sulfonate (household detergent, MBAS)	.5 mg/l	
Nitrate (as N)	10 mg/l 4/	
Sulfate (SO_4)	250 mg/l	
Total dissolved solids (1,000 acceptable if no other water is available)	500 mg/l	
Zinc (Zn)	5,000 µg/l	

1/ µg/l, micrograms per liter
2/ mg/l, milligrams per liter
3/ Fluoride limits are based on annual average of maximum daily air temperatures.
4/ 10 mg/l nitrate (as N) is equivalent to 45 mg/l nitrate (as NO_3).

The purpose of this study, which began in July 1971, was to determine the quality of ground water relative to generally accepted standards for drinking water and to determine the areal distribution of constituents that are indicative of septic-tank effluent. Water-supply wells and U.S. Bureau of Reclamation observation wells were inventoried and depth to water was measured. Land-surface altitudes were taken from the Helena and East Helena 15-minute topographic quadrangles and a water-level contour map was prepared. Samples of water from selected wells throughout the valley were analyzed for inorganic chemical constituents and the presence of coliform bacteria. Analytical results are presented, and the values used to describe the quality of the ground water. A short glossary and the tables of basic data are included at the end of the report.

The cooperation of area residents and the U.S. Bureau of Reclamation in allowing water-level measurements and collection of water samples from their wells is sincerely appreciated. The study was aided greatly by the Montana Department of Health whose personnel made most of the bacteriological analyses. Keith Trafton and Dave Thomas of the City-County Health Department assisted in project planning and helped collect water samples for bacteriological analyses. Much credit is due Ron King, summer field assistant, for the well inventory, water-level measurement, and water-sample collection.

System for specifying geographic locations

Location numbers for wells or other sites are derived from the General Land Office system of land subdivision. The first three characters of the location number specify the township, the next two the range, the next one or two the section number within the township, and the next three the location within the quarter section (160-acre tract), the quarter-quarter section (40-acre tract), and the quarter-quarter-quarter section (10-acre tract). Subdivisions of a section are designated a, b, c, and d in a counterclockwise direction, beginning in the northeast quadrant. If there is more than one well or location in a 10-acre tract, consecutive digits beginning with 2 for the second well are added to the location number. For example, a well numbered 10N4W23bac2 would be the second well inventoried in the SW¼ of the NE¼ of the NW¼ of section 23, Township 10 North, Range 4 West. This system of specifying location is shown in figure 2.

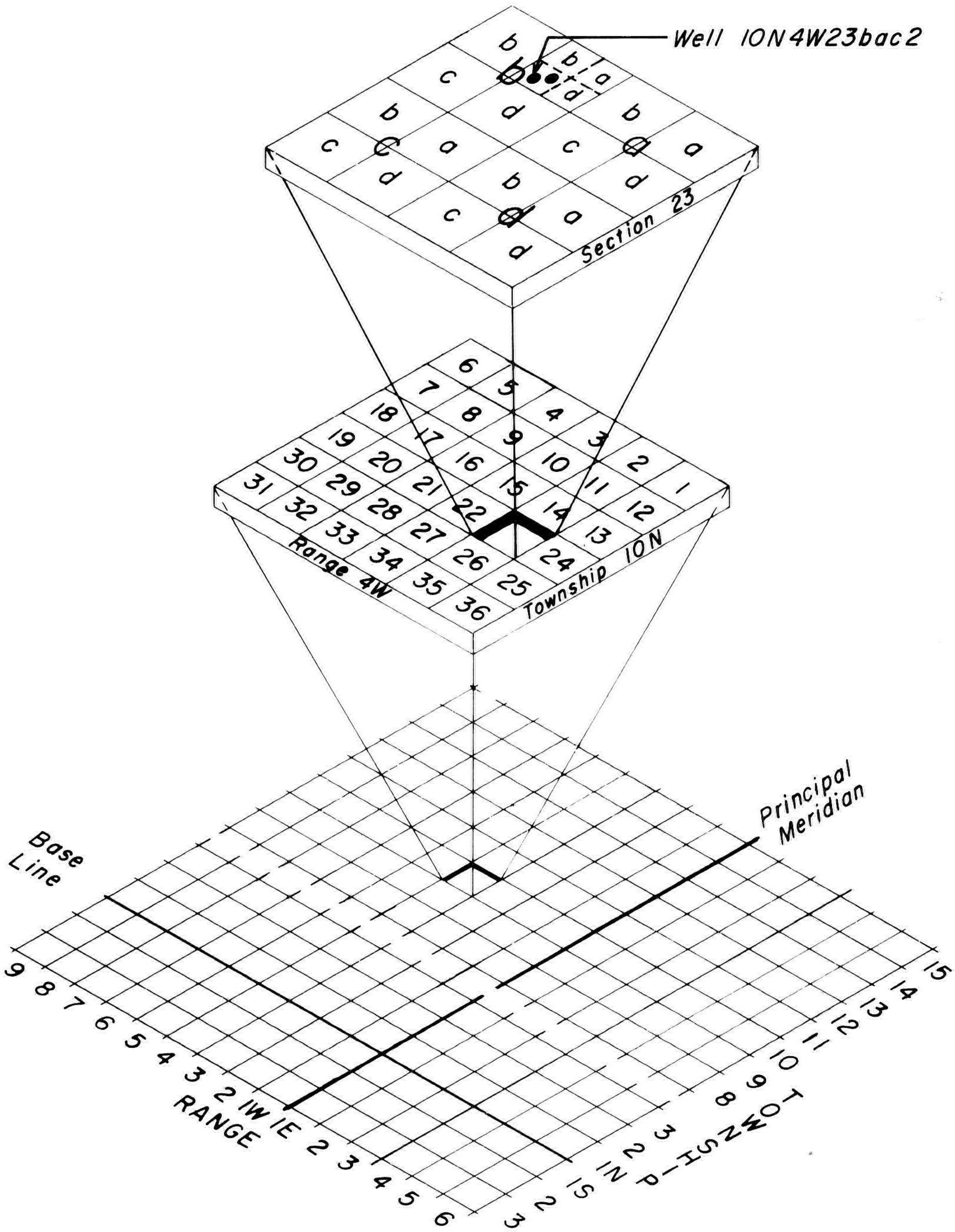

Figure 2.—System of specifying locations

Geographic setting

Helena valley (fig. 1), in west-central Montana, includes about 95 square miles in Lewis and Clark County. The towns of Helena and East Helena are on the south border of the valley.

The altitude of the valley floor ranges from about 3,650 feet above sea level at the northeast corner of the area (approximate level of Lake Helena) to about 4,000 feet along the western and southern edges. Hills and mountains surrounding the valley reach altitudes of 5,000 to 6,000 feet.

Prickly Pear Creek flows into the valley at East Helena, flows northwest, then north where it joins Tenmile Creek. Tenmile Creek, joined by Sevenmile Creek at the southwestern corner of the study area, flows northeastward across the valley. Silver Creek enters the valley at the northwest corner, flows southeastward and then northeastward; it is dry during the late summer. Creeks entering the west edge of the study area head in the mountains along the Continental Divide. Prickly Pear Creek heads in the mountains south of the study area. All drainage in the valley is toward Lake Helena, backwater from Hauser Lake of the Missouri River.

Geohydrologic setting

The Helena valley probably formed during middle to late Tertiary time. Basin-fill deposits in the valley range in age from middle Tertiary through Quaternary. The older basin-fill deposits (Oligocene to Miocene in age) crop out in the southern and eastern parts of the study area and occur at depth, covered by Quaternary deposits, throughout the rest of the valley. The general character of the basin-fill deposits has been reported by previous workers (Knopf, 1913; Pardee, 1925; Pardee and Schrader, 1933; Lorenz and Swenson, 1951; and Knopf, 1963); however, little detailed information on the extent and thickness of the various materials composing the deposits is available.

In general, the basin-fill deposits consist of clay and silt interbedded with sand and gravel, but the composition varies greatly from area to area; volcanic ash, volcanic flows, and layers of lignite are present in some places. Sand and gravel occur as discontinuous lenses, but make up a large percentage of the basin-fill deposits. The full thickness of the basin-fill deposits is not known. Water wells, reportedly drilled as much as 1,200 feet deep (Knopf, 1913, p. 94) in search of artesian water, did not reach the base of the deposits.

The composition of the basin-fill aquifer to a large degree determines its permeability, which is an important control on the movement of the water. It appears that, despite a variable composition, water moves freely through the basin-fill aquifer in most areas of the valley. Beds of clay occur at shallow depths (15 to 40 feet) throughout much of the valley and are associated with hardpan development in many places. The beds probably do not form a continuous layer, but where present they retard the downward movement of water.

The hills and mountains surrounding the valley are composed of folded and faulted igneous, sedimentary, and metamorphic rocks that range in age from Precambrian to Tertiary. Numerous faults have been mapped in the bedrock flanking the valley (Knopf, 1963). These faults have been traced to the edge of the valley where they presumably continue in bedrock beneath or, possibly, cut some of the basin-fill deposits. Scott (1936) proposed a major fault (epicenter of the 1935 Helena earthquakes) trending west-northwest at the north edge of the present city limits of Helena. Better understanding of the fault system would aid in describing the character and distribution of the basin-fill deposits.

The depth to water was measured during July and August, 1971, in 229 wells (table 1). The altitude of the water level was calculated and used in drawing the water-level contours (fig. 3). The general direction of ground-water movement is shown by lines, which are nearly at right angles to the contours.

Recharge during July, August, and September is principally from irrigation water. A large irrigation supply canal (fig. 3) partly encircles the Helena valley. The source of the water is the Helena Valley Regulating Reservoir (built by the U.S. Bureau of Reclamation), which receives and stores water pumped from the Missouri River.

Other important sources of recharge are precipitation, stream losses, and ground-water inflow through the deposits along Tenmile, Prickly Pear, and Silver Creeks. Recharge from precipitation and stream loss is minimal during the winter, but increases during May to peak in June. The water-level contours (fig. 3) show that Tenmile Creek is a losing stream (water is moving from the creek into the aquifer) in the reach from 10N4W12d to 10N3W5d. Prickly Pear Creek is a losing stream from 10N3W25b to 10N3W22a. Recharge from lawn irrigation and effluent from septic tanks provide a relatively small part of the total amount of recharge.

Water levels in the Helena valley are usually highest during the irrigation season when they range from 2 to 30 feet below land surface in most of the area. The map (fig. 3) was drawn from data collected in July and August and therefore it shows the highest water level. Water levels decline during the fall and winter.

Table 1.--Record of wells

Explanation

Well number: See text for description of well-numbering system
Type of casing: P, pipe; C, concrete.
Method of lift: N, none; J, jet; S, submersible.
Type of power: N, none; E, electric.
Use of water: O, observation of water level; S, stock; I, irrigation; D, domestic; P, public; N, not being used; In, industrial; Gi, garden irrigation.
Type of well: Dn, driven; Dr, drilled; Du, dug.
Altitude of land surface: Expressed in feet above mean sea level and obtained from topographic maps.
Remarks: USBR, U.S. Bureau of Reclamation observation well; C, water sample collected for chemical analysis for common constituents; N, water sample collected for analysis for constituents that may indicate man's activities; T, water sample collected for trace element analysis; B, water sample collected for bacteria analysis.

Well number	Year drilled	Depth of well (feet)	Diameter of well (inches)	Type of casing	Method of lift	Type of power	Use of water	Type of well	Altitude of land surface (feet)	Depth to water below land surface (feet)	Date of measurement	Remarks
10N2W6bcc	--	8.0	1.0	P	N	N	O	Dn	3,696	3.9	7-8-71	USBR
10N2W6dad	--	--	6.0	P	-	E	D	Dr	3,720	27.8	8-3-71	--
10N2W6dcd	--	34.0	6.0	P	J	E	D	Dr	3,703	4.4	7-29-71	--
10N2W7aaa	--	16.0	1.5	P	N	N	O	Dn	3,718	10.9	7-8-71	USBR
10N2W7aad	--	29.0	1.5	P	N	N	O	Dn	3,720	7.9	7-8-71	USBR
10N2W7ada	--	18.0	2.0	P	N	N	O	Dn	3,720	3.0	7-9-71	USBR
10N2W7baa	--	38.0	6.0	P	S	E	D	Dr	3,714	5.6	7-29-71	N, B
10N2W7bba	--	18.0	1.5	P	N	N	O	Dn	3,712	5.8	7-8-71	USBR
10N2W7bba2	--	40.0	6.0	P	S	E	D	Dr	3,714	4.9	7-29-71	--
10N2W7bbb	--	19.0	1.5	P	N	N	O	Dn	3,721	6.9	7-8-71	USBR
10N2W7bbc	--	19.0	1.5	P	N	N	O	Dn	3,721	9.7	7-8-71	USBR

Table 1.--Record of wells--Continued

Well number	Year drilled	Depth of well (feet)	Diameter of well (inches)	Type of casing	Method of lift	Type of power	Use of water	Type of well	Altitude of land surface (feet)	Depth to water below land surface (feet)	Date of measurement	Remarks
10N2W7ddd	--	19.0	1.5	P	N	N	O	Dn	3,744	7.4	7-8-71	USBR
10N2W18abb	--	20.0	1.5	P	N	N	O	Dn	3,745	16.2	7-9-71	USBR
10N2W19aad	--	74.0	6.0	P	S	E	D	Dr	3,794	39.4	7-29-71	N, T, B
10N2W29bcc	--	80.0	6.0	P	-	E	-	Dr	3,861	32.9	8-3-71	N, T, B
10N2W31aba	--	--	6.0	P	-	E	D	Dr	3,897	--	--	T, B
10N3W1dcc	--	18.0	1.5	P	N	N	O	Dn	3,717	6.3	7- -71	USBR
10N3W2acc	--	3.0	1.0	P	N	N	O	Dn	3,695	2.6	7-9-71	USBR
10N3W2add	--	6.0	1.0	P	N	N	O	Dn	3,698	5.0	7-8-71	USBR
10N3W2bdd	--	40.0	6.0	P	-	E	-	Dr	3,696	4.0	8-4-71	N
10N3W2dcc	--	33.0	6.0	P	S	E	D	Dr	3,714	2.2	8-4-71	--
10N3W3abb	--	10.0	1.5	P	N	N	O	Dn	3,683	2.7	7- -71	USBR
10N3W3cab	--	43.6	6.0	P	J	E	D	Dr	3,693	4.8	7-30-71	C, B
10N3W3cac	1962	50.0	6.0	P	S	E	S	Dr	3,693	4.1	7-30-71	N
10N3W4abb	--	8.0	1.5	P	N	N	O	Dn	3,681	4.2	7- -71	USBR
10N3W5aba	1922	42.0	8.0	P	J	E	D	Dr	3,710	4.8	7- -71	C
10N3W5bac	1966	123.0	8.0	P	-	E	P	Dr	3,722	9.2	7-15-71	--
10N3W5bbb	--	--	6.0	P	J	E	P	Dr	3,724	17.2	7-14-71	--
10N3W5bda	--	9.0	1.0	P	N	N	O	Dn	3,720	8.0	7- -71	USBR
10N3W5cbc	--	70.0	6.0	P	J	E	D	Dr	3,742	27.2	7-21-71	--
10N3W5dcd	--	11.0	1.0	P	N	N	O	Dn	3,733	2.8	7- -71	USBR
10N3W6aad	1949	43.0	--	P	-	E	D	Dr	3,732	12.8	7-14-71	--
10N3W6acd	--	48.0	6.0	P	S	E	D	Dr	3,740	16.2	7-14-71	C
10N3W6add	--	45.0	6.0	P	-	E	D	Dr	3,736	21.0	7-14-71	N, B
10N3W6bbb	--	--	6.0	P	-	E	D	Dr	3,743	12.2	7-14-71	--
10N3W6bcc	--	--	6.0	P	-	E	D	Dr	3,755	19.6	7-14-71	N, B
10N3W6caa	--	45.0	6.0	P	-	E	D	Dr	3,752	19.1	7-14-71	N, B
10N3W6cba	1967	44.0	6.0	P	-	E	D	Dr	3,756	19.8	7- -71	--
10N3W6ccd	--	--	6.0	P	-	E	D	Dr	3,766	10.7	7-14-71	--
10N3W6cdc	--	65.0	6.0	P	S	E	D	Dr	3,766	10.4	7-14-71	N, B
10N3W6dab	--	43.0	6.0	P	-	E	D	Dr	3,741	13.6	7-15-71	--

Table 1.--Record of wells--Continued

Well number	Year drilled	Depth of well (feet)	Diameter of well (inches)	Type of casing	Method of lift	Type of power	Use of water	Type of well	Altitude of land surface (feet)	Depth to water below land surface (feet)	Date of measurement	Remarks
10N3W6dca	--	42.0	6.0	P	S	E	D	Dr	3,749	14.2	7-15-71	N, B
10N3W6ddc	--	--	6.0	P	J	E	D	Dr	3,753	13.9	7-15-71	--
10N3W6ddd	--	45.0	6.0	P	S	E	D	Dr	3,749	9.8	7-16-71	--
10N3W7aaa	1970	40.0	6.0	P	S	E	D	Dr	3,752	8.3	7-16-71	N, B
10N3W7aab	--	50.0	--	C	-	-	D	Du	3,757	11.5	7-15-71	--
10N3W7abb	--	42.0	6.0	P	S	E	D	Dr	3,762	9.2	7- -71	C, B
10N3W7abb2	--	42.0	6.0	P	J	E	D	Dr	3,762	15.2	7-15-71	--
10N3W7abd	--	40.0	6.0	P	-	E	D	Dr	3,761	9.7	7-16-71	--
10N3W7acb	1968	45.0	6.0	P	S	E	D	Dr	3,772	7.6	7- -71	--
10N3W7acc	--	7.0	2.0	P	N	N	O	Dn	3,776	2.8	7- -71	USBR
10N3W7ada	--	--	6.0	P	S	E	D	Dr	3,759	7.7	7-16-71	--
10N3W7add	--	50.0	6.0	P	-	E	D	Dr	3,763	8.3	7-16-71	--
10N3W7add2	--	40.0	6.0	P	-	E	D	Dr	3,763	11.4	7-16-71	N, B
10N3W7baa	--	60.0	6.0	P	S	E	D	Dr	3,761	7.8	7- -71	--
10N3W7dbc	--	32.0	6.0	P	S	E	D	Dr	3,782	6.4	7- -71	N
10N3W7ddc	--	65.0	6.0	P	S	E	D	Dr	3,785	20.9	7-16-71	N, B
10N3W7ddd	--	53.0	6.0	P	S	E	D	Dr	3,782	22.2	7-16-71	--
10N3W8acc	1956	120.0	12.0	P	J	E	I	Dr	3,745	6.8	7-21-71	--
10N3W8adc	--	60.0	6.0	P	S	E	D	Dr	3,740	5.6	7-21-71	N, B
10N3W8bba	--	60.0	6.0	P	S	E	D	Dr	3,748	9.6	7-19-71	N, B
10N3W8bbb	--	15.0	48.0	C	-	E	I	Du	3,751	6.0	7-19-71	--
10N3W8bbc	1955	41.0	6.0	P	J	E	D	Dr	3,755	10.7	7-19-71	--
10N3W8ccd	1967	53.0	6.0	P	S	E	D	Dr	3,770	19.2	7-19-71	--
10N3W8cdd	1967	52.0	6.0	P	S	E	D	Dr	3,761	21.3	7-19-71	N, B
10N3W9dad	1962	8.0	48.0	C	-	E	I	Du	3,716	3.8	7-29-71	--
10N3W9dda	--	82	6.0	P	J	E	D	Dr	3,718	+ .6	7-29-71	N, B
10N3W10bad	--	12.0	12.0	P	N	N	N	Du	3,712	2.9	7-30-71	--
10N3W10dbc	--	8.0	1.0	P	N	N	O	Dn	3,720	3.6	7- -71	USBR
10N3W10dcd	--	3.0	1.0	P	N	N	O	Dn	3,732	2.8	7- -71	USBR
10N3W10ddc	--	50.0	6.0	P	S	E	D	Dr	3,736	4.4	7-29-71	--
10N3W11aaa	--	35.0	6.0	P	J	E	D	Dr	3,719	10.2	7-29-71	N

Table 1.--Record of wells--Continued

Well number	Year drilled	Depth of well (feet)	Diameter of well (inches)	Type of casing	Method of lift	Type of power	Use of water	Type of well	Altitude of land surface (feet)	Depth to water below land surface (feet)	Date of measurement	Remarks
10N3W11aac	--	30.0	6.0	P	-	E	D	Dr	3,724	8.6	7-29-71	--
10N3W11acc	--	57.0	6.0	P	J	E	D	Dr	3,734	7.9	7-26-71	--
10N3W11cca	--	40.0	6.0	P	S	E	P	Dr	3,740	6.6	7-29-71	N, T, B
10N3W11daa	--	46.0	6.0	P	J	E	D	Dr	3,740	20.3	8-3-71	N, B
10N3W11dbd	1918	60.0	6.0	P	S	E	D	Dr	3,744	10.7	8-4-71	C, B
10N3W12aaa	--	35.0	6.0	P	-	E	D	Dr	3,720	6.7	7-29-71	N, T, B
10N3W12baa	--	53.0	6.0	P	-	E	D	Dr	3,719	7.7	7-29-71	--
10N3W12bbb	--	45.0	6.0	P	J	E	D	Dr	3,720	12.5	8-3-71	--
10N3W13bbb	--	40.0	36.0	C	N	N	N	Du	3,760	25.9	8-4-71	--
10N3W13cdd	--	64.0	6.0	P	S	E	D	Dr	3,794	37.8	7-29-71	N, B
10N3W14aac	1966	46.0	6.0	P	S	E	D	Dr	3,761	19.1	8-4-71	--
10N3W14add	--	61.0	6.0	P	-	-	D	Dr	3,773	22.0	8-3-71	N, B
10N3W15baa	--	20.0	48.0	C	J	E	I	Du	3,733	4.7	7-29-71	--
10N3W15bad	--	79.0	6.0	P	S	E	D	Dr	3,730	7.4	7-29-71	C, B
10N3W15bda	--	28.0	6.0	P	J	E	I	Dr	3,728	5.3	7-30-71	--
10N3W15bdb	--	8.0	2.0	P	N	N	O	Dn	3,726	6.6	7- -71	USBR
10N3W16adb	--	30.0	6.0	P	J	E	D	Dr	3,740	11.8	7-30-71	--
10N3W16dca	--	60.0	6.0	P	J	E	D	Dr	3,768	14.4	7-30-71	C, B
10N3W16ddc	--	50.0	6.0	P	J	E	D	Dr	3,777	28.6	7-30-71	--
10N3W17aba	--	60.0	6.0	P	J	E	D	Dr	3,761	10.6	7-21-71	C, B
10N3W17abb	--	67.0	6.0	P	S	E	D	Dr	3,770	20.4	7-21-71	--
10N3W17aca	--	40.0	1.5	P	N	N	O	Dn	3,773	31.4	7- -71	--
10N3W17ddc	--	189.0	8.0	P	J	E	D	Dr	3,813	54.9	7-19-71	--
10N3W18aaa	1954	40.0	6.0	P	J	E	I	Dr	3,786	22.5	7-16-71	--
10N3W18ada	1961	59.0	6.0	P	-	E	D	Dr	3,800	36.3	7- -71	--
10N3W18ada2	--	41.2	6.0	P	S	E	D	Dr	3,800	37.2	7- -71	N, B
10N3W18adb	--	90.0	6.0	C,P	J	E	D	Du,Dr	3,808	41.7	7-16-71	C
10N3W18baa	--	52.0	6.0	P	S	E	D	Dr	3,799	18.6	7- -71	N, B
10N3W18bac	--	56.0	6.0	P	S	E	D	Dr	3,801	14.3	7-19-71	--
10N3W18cbd	--	90.0	6.0	P	S	E	D	Dr	3,839	21.5	7-19-71	--
10N3W18ccc	--	53.0	6.0	P	J	E	D	Dr	3,860	36.9	7-19-71	N, B

Table 1.--Record of wells--Continued

Well number	Year drilled	Depth of well (feet)	Diameter of well (inches)	Type of casing	Method of lift	Type of power	Use of water	Type of well	Altitude of land surface (feet)	Depth to water below land surface (feet)	Date of measurement	Remarks
10N3W18cdd	--	86.0	6.0	P	S	E	D	Dr	3,850	13.5	7-19-71	N, B
10N3W18dbb	--	40.0	4.0	P	J	E	D	Dr	3,840	39.5	7-19-71	N
10N3W18ddd	--	66.0	6.0	P	J	E	D	Dr	3,843	27.2	7-19-71	N, B
10N3W19aaa	--	--	6.0	P	-	E	P	Dr	3,856	29.2	7-20-71	--
10N3W19acc	--	23	48.0	C	J	E	Gi	Du	3,912	9.4	7-28-71	C
10N3W22bac	1909	55.0	48.0	C	J	E	S	Du	3,790	27.2	7-29-71	N
10N3W23aac	1935	98.0	6.0	P	J	E	In	Dr	3,803	30.4	8-4-71	--
10N3W23bbb	1955	40.0	6.0	P	J	E	D	Dr	3,775	13.4	7-29-71	N, B
10N3W24cbd	--	60.0	6.0	P	J	E	D	Dr	3,824	32.1	8-4-71	C, T, B
10N3W25bbb	--	60.0	8.0	P	J	E	I	Dr	3,839	30.4	8-4-71	N, T, B
10N3W26cab	1955	80.0	6.0	P	-	E	D	Dr	3,908	44.6	8-4-71	--
10N3W26cad	1962	111.0	6.0	P	J	E	D	Dr	3,930	11.0	8-4-71	--
10N3W26ccd	--	44.0	4.0	P	J	E	D	Dr	3,960	11.6	8-4-71	T
10N3W27ddc	--	43.0	12.0	P	N	N	N	Dr	3,980	27.9	8-4-71	--
10N4W1aab	--	76.0	6.0	P	S	E	D	Dr	3,756	17.6	7-20-71	N, B
10N4W12dad	--	--	6.0	P	S	E	D	Dr	3,801	4.9	7-21-71	N, B
10N4W12ddc	--	12.0	12.0	C	-	-	I	Du	3,810	5.1	7-20-71	--
10N4W13cbb	1968	35.0	6.0	P	J	E	P	Dr	3,850	6.5	7-21-71	N, B
10N4W13cdd	--	--	6.0	P	J	E	D	Dr	3,840	5.2	7-20-71	--
10N4W13dcd	--	63.0	6.0	P	J	E	D	Dr	3,850	30.8	7-20-71	--
10N4W13ddd	1957	63.0	6.0	P	J	E	D	Dr	3,860	40.4	7-21-71	--
10N4W14bba	1910	18.0	48.0	C	J	E	Gi	Du	3,900	9.1	7-22-71	N, B
10N4W15baa	--	--	6.0	P	S	E	D	Dr	3,950	29.8	7-21-71	N, B
10N4W15bbb	--	63.0	6.0	P	S	E	D	Dr	3,980	25.4	7-21-71	--
10N4W15dbb	1959	38.0	6.0	P	J	E	D	Dr	3,933	16.2	7-21-71	C
10N4W22aca	--	30.0	--	-	N	N	N	Du	3,935	13.1	8-13-71	--
10N4W23aad	1971	79.0	6.0	P	S	E	D	Dr	3,885	4.7	7-23-71	N, B
10N4W23bab	--	60.0	6.0	P	J	E	D	Dr	3,889	2.5	7-22-71	C, B
10N4W23bac	1946	8.0	48.0	C	N	N	N	Du	3,898	6.5	7-22-71	--
10N4W23bac2	1946	38.0	6.0	P	J	E	D	Dr	3,898	7.5	7-22-71	N

Table 1.--Record of wells--Continued

Well number	Year drilled	Depth of well (feet)	Diameter of well (inches)	Type of casing	Method of lift	Type of power	Use of water	Type of well	Altitude of land surface (feet)	Depth to water below land surface (feet)	Date of measurement	Remarks
10N4W23dad	1971	93.0	6.0	P	S	E	D	Dr	3,980	67.8	7-28-71	--
10N4W23dbb	1969	47.0	6.0	P	J	E	D	Dr	3,920	38.0	7-23-71	--
11N2W30cca	--	13.0	2.0	P	N	N	O	Dn	3,665	6.4	7-8-71	USBR
11N2W31acc	--	--	6.0	P	J	E	D	Dr	3,684	2.6	8-2-71	--
11N2W31bbb	--	9.0	1.0	P	N	N	O	Dn	3,668	7.0	7-8-71	USBR
11N2W31bbc	--	12.0	1.5	P	N	N	O	Dn	3,670	3.9	7-8-71	USBR
11N2W31bcb	--	28.0	6.0	P	J	E	I	Dr	3,672	5.3	8-3-71	N
11N2W31bcc	--	8.0	1.0	P	N	N	O	Dn	3,675	4.2	7-9-71	USBR
11N2W31cac	--	--	18.0	C	N	N	N	Du	3,680	5.9	8-2-71	--
11N3W14cad	--	10.0	.5	P	N	N	O	Dn	3,680	3.9	7-30-71	USBR
11N3W14cbd	--	10.0	.5	P	N	N	O	Dn	3,685	3.5	7-30-71	USBR
11N3W15cdd	--	13.0	1.0	P	N	N	O	Dn	3,670	5.5	7-9-71	USBR
11N3W15dcd	--	13.0	1.0	P	N	N	O	Dn	3,670	6.7	7-9-71	USBR
11N3W17ccd	--	21.0	1.0	P	N	N	O	Dn	3,743	3.6	7- -71	USBR
11N3W17cdd	--	41.0	6.0	P	S	E	D	Dr	3,737	2.6	7-28-71	--
11N3W17ddd	--	12.0	1.5	P	N	N	O	Dn	3,717	7.1	7-7-71	USBR
11N3W18dcd	--	--	6.0	P	S	E	P	Dr	3,765	24.1	7-25-71	N, B
11N3W19add	--	5.0	1.0	P	N	N	O	Dn	3,745	3.5	7-9-71	USBR
11N3W19dbc	--	45.0	6.0	P	S	E	D	Dr	3,750	19.1	7-28-71	N
11N3W20cbc	--	9.0	1.0	P	N	N	O	Dn	3,736	1.2	7-7-71	USBR
11N3W20ccc	--	5.0	1.0	P	N	N	O	Dn	3,727	2.0	7-7-71	USBR
11N3W20ddc	--	9.0	1.5	P	N	N	O	Dn	3,706	2.3	7- -71	USBR
11N3W21baa	--	10.0	1.5	P	N	N	O	Dn	3,685	3.1	7- -71	USBR
11N3W21cab	--	10.0	1.0	P	N	N	O	Dn	3,685	7.7	7- -71	USBR
11N3W21ccb	--	10.0	1.5	P	N	N	O	Dn	3,695	8.2	7-7-71	USBR
11N3W21ccc	--	10.0	1.5	P	N	N	O	Dn	3,693	5.9	7- -71	USBR
11N3W21dcc	--	23.0	48.0	C	J	E	I	Du	3,678	2.7	7-30-71	C
11N3W21dda	--	10.0	1.5	P	N	N	O	Dn	3,670	4.2	7- -71	USBR
11N3W22ccc	--	14.0	1.0	P	N	N	O	Dn	3,660	6.1	7- -71	USBR
11N3W25dcb	--	10.0	1.0	P	N	N	O	Dn	3,663	.5	7- -71	USBR
11N3W25dda	--	10.0	1.0	P	N	N	O	Dn	3,666	4.8	7-8-71	USBR

Table 1.--Record of wells--Continued

Well number	Year drilled	Depth of well (feet)	Diameter of well (inches)	Type of casing	Method of lift	Type of power	Use of water	Type of well	Altitude of land surface (feet)	Depth to water below land surface (feet)	Date of measurement	Remarks
11N3W25ddb	--	13.0	1.0	P	N	N	O	Dn	3,664	3.8	7-12-71	USBR
11N3W29abb	--	--	6.0	P	J	E	D	Dr	3,707	2.3	7-28-71	N, B
11N3W29acc	--	11.0	1.0	P	N	N	O	Dn	3,697	8.3	7-8-71	USBR
11N3W29baa	--	--	6.0	P	-	E	D	Dr	3,713	9.6	7-25-71	--
11N3W29bac	--	--	6.0	P	S	E	D	Dr	3,711	+ .7	7- -71	N, B
11N3W29bbb	--	--	6.0	P	S	E	D	Dr	3,720	+1.5	7-25-71	--
11N3W29bcc	--	12.0	2.0	P	N	N	O	Dn	3,713	3.9	7- -71	USBR
11N3W29ccb	--	40.0	6.0	P	S	E	S	Dr	3,706	6.7	7-25-71	N, B
11N3W30abb	--	50.0	6.0	P	N	N	N	Dr	3,740	15.9	7- -71	--
11N3W30daa	1971	10.0	4.0	-	N	N	O	Dn	3,715	5.7	7-25-71	N
11N3W30dad	--	52.0	6.0	P	J	E	D	Dr	3,714	2.3	7-25-71	C
11N3W30dbb	--	5.0	6.0	P	J	E	D	Dr	3,724	5.6	7-25-71	--
11N3W30dbc	1971	10.0	4.0	-	N	N	O	Dn	3,720	7.2	7-25-71	--
11N3W30dbd	--	57.0	6.0	P	J	E	D	Dr	3,718	4.7	7-25-71	N, B
11N3W30ddb	1971	10.0	4.0	-	N	N	O	Dn	3,711	6.2	7-25-71	--
11N3W31adc	--	48.0	6.0	P	S	E	D	Dr	3,712	5.7	7-25-71	--
11N3W31daa	--	47.0	6.0	P	S	E	D	Dr	3,715	11.3	7-25-71	--
11N3W31dab	--	--	6.0	P	S	E	D	Dr	3,718	8.6	7-25-71	--
11N3W31dbc	--	55.0	6.0	P	J	E	D	Dr	3,722	13.9	7-25-71	N, B
11N3W31dcc	--	--	6.0	P	J	E	D	Dr	3,732	10.1	7-26-71	N, B
11N3W31dcd	--	39.0	6.0	P	J	E	D	Dr	3,730	12.7	7-26-71	--
11N3W31dda	--	--	6.0	P	-	E	D	Dr	3,720	8.9	7-25-71	--
11N3W31dda2	--	54.0	6.0	P	S	E	D	Dr	3,721	9.8	--	N, T, B
11N3W31ddd	--	--	6.0	P	J	E	D	Dr	3,723	12.0	7-25-71	--
11N3W31ddd2	--	30.0	6.0	P	J	E	D	Dr	3,723	11.7	7-25-71	--
11N3W32aaa	--	54.0	6.0	P	S	E	D	Dr	3,685	.1	7-28-71	N, B
11N3W32aad	--	10.0	.5	P	N	N	O	Dn	3,688	5.3	7-28-71	USBR
11N3W32acc	--	9.0	1.0	P	N	N	O	Dn	3,703	8.8	7-8-71	USBR
11N3W32cab	--	--	6.0	P	S	E	D	Dn	3,708	6.2	7-23-71	C, B
11N3W32cac	1959	40.0	6.0	P	J	E	D	Dr	3,710	6.5	7-23-71	N, B
11N3W32cba	--	35.0	6.0	P	S	E	D	Dr	3,710	5.4	7-23-71	--

Table 1.--Record of wells--Continued

Well number	Year drilled	Depth of well (feet)	Diameter of well (inches)	Type of casing	Method of lift	Type of power	Use of water	Type of well	Altitude of land surface (feet)	Depth to water below land surface (feet)	Date of measure-ment	Remarks
11N3W32cbb	--	30.5	6.0	P	S	E	D	Dr	3,713	4.3	7-23-71	N, B
11N3W32cbc	--	--	6.0	P	S	E	D	Dr	3,714	6.8	7-26-71	--
11N3W32ccd	--	40.0	6.0	P	J	E	D	Dr	3,720	8.8	7-23-71	N, B
11N3W32cdb	--	--	6.0	P	J	E	D	Dr	3,716	7.1	7-25-71	--
11N3W32cdd	1956	40.0	6.0	P	J	E	D	Dr	3,715	8.8	7-23-71	--
11N3W32daa	--	10.0	1.0	P	N	N	O	Dn	3,693	6.8	7- -71	USBR
11N3W32dab	--	12.0	.5	P	N	N	O	Dn	3,697	7.2	7-28-71	USBR
11N3W32dbb	1951	38.0	6.0	P	-	E	D	Dr	3,702	5.5	7-28-71	N, B
11N3W32dcc	--	10.0	1.0	P	N	N	O	Dn	3,713	7.2	7- -71	USBR
11N3W33cdd	--	45.0	6.0	P	S	E	D	Dr	3,682	4.0	7-30-71	N, B
11N3W33dac	--	25.0	6.0	P	J	E	D	Dr	3,679	8.2	7-30-71	C, B
11N3W34aaa	--	9.0	1.0	P	N	N	O	Dn	3,664	4.7	7- -71	USBR
11N3W34bac	--	8.0	1.0	P	N	N	O	Dn	3,668	5.8	7- -71	USBR
11N3W34ccc	--	8.0	1.5	P	N	N	O	Dn	3,679	5.3	7- -71	USBR
11N3W35ada	--	10.0	1.0	P	N	N	O	Dn	3,670	2.8	7- -71	USBR
11N3W35dda	--	9.0	1.0	P	N	N	O	Dn	3,678	3.8	7- -71	USBR
11N3W36ccd	--	45.0	6.0	P	S	E	D	Dr	3,684	3.7	8-3-71	N, T, B
11N4W13ccc	--	93.0	6.0	P	S	E	D	Dr	3,855	63.5	7-28-71	N, B
11N4W13ddd	--	85.0	6.0	P	J	E	D	Dr	3,801	64.6	7-28-71	C, B
11N4W24aad	--	100.0	6.0	P	J	E	D	Dr	3,792	31.4	7-26-71	--
11N4W24abb	--	100.0	6.0	P	S	E	D	Dr	3,820	76.7	7-28-71	--
11N4W24abd	--	100.0	6.0	P	S	E	D	Dr	3,810	73.3	7-28-71	--
11N4W24cab	--	100.0	6.0	P	J	E	D	Dr	3,822	68.8	7-26-71	--
11N4W24daa	--	90.0	6.0	P	J	E	D	Dr	3,788	59.1	7-28-71	N
11N4W25ada	--	50.0	6.0	P	J	E	D	Dr	3,758	32.9	7-26-71	--
11N4W25add	1965	57.0	6.0	P	J	E	D	Dr	3,755	24.2	7-26-71	--
11N4W25baa	--	90.0	6.0	P	S	E	D	Dr	3,796	62.2	7-26-71	N, B
11N4W25bab	--	100.0	6.0	P	S	E	D	Dr	3,813	92.4	7-26-71	--
11N4W25cdc	--	120.0	6.0	P	S	E	D	Dr	3,833	107.4	7-26-71	--
11N4W25daa	--	60.0	6.0	P	J	E	D	Dr	3,753	22.7	7-26-71	N, B
11N4W25dcd	--	--	6.0	P	S	E	D	Dr	3,770	46.6	7-26-71	--

Table 1.--Record of wells--Continued

Well number	Year drilled	Depth of well (feet)	Diameter of well (inches)	Type of casing	Method of lift	Type of power	Use of water	Type of well	Altitude of land surface (feet)	Depth to water below land surface (feet)	Date of measurement	Remarks
11N4W25ddc	--	74.0	6.0	P	S	E	D	Dr	3,750	27.0	7-26-71	N, B
11N4W36baa	--	110.0	6.0	P	S	E	D	Dr	3,800	72.1	7-26-71	N, B
11N4W36dad	--	8.0	1.0	P	N	N	O	Dn	3,735	4.5	7- -71	USBR

Lorenz and Swenson (1951) indicate that (at the time of their study) the outer edges of the valley had the highest water-level altitudes in June as a result of spring runoff. Since their report was prepared, the hydrologic regimen has changed because irrigation in the valley has increased and a system of drains has been dug by the U.S. Bureau of Reclamation.

Ground water is discharged by evapotranspiration and by flow into the lower reaches of Prickly Pear, Tenmile, and Silver Creeks, a system of drainage ditches, and Lake Helena directly. Withdrawals from wells constitute a relatively small, but important, part of groundwater discharge.

Well construction

Two types of well construction predominate in the Helena valley. The first type is a drilled or driven well which is 2 to 8 inches in diameter and is cased with metal. Most casings are open only at the bottom of the casing but some are perforated. The second type is a hand- or machine-dug well cased with wood, brick, cement, or metal. Dug wells, generally, are shallow, open only at the bottom, and 2 to 4 feet in diameter. Some wells are a combination; a dug well which has been deepened by drilling or driving a smaller diameter casing inside the old well. Wells are used mainly to supply stock, domestic, and irrigation water. Dug wells generally have smaller yields than deeper drilled wells, but supply enough water for domestic- and stock-supply purposes.

Collection and handling of water samples

Three suites of samples were collected. The first suite of water samples was collected to determine the general character of the ground water. This suite of 20 samples was analyzed for the more common inorganic constituents and detergent (Methylene Blue Active Substance, MBAS). Included were 18 samples collected from wells and a sample from Lake Helena and one from the Helena Valley Regulating Reservoir (table 2). The second suite of samples was collected to determine the effect of septic-tank effluent on the ground water. The second suite included 69 samples analyzed for constituents indicative of man's activities (table 3) and 65 samples analyzed for the presence of coliform bacteria. The third suite of 10 samples was collected to determine the effect of industrial processes on the ground water. This suite of 10 samples was analyzed for selected trace elements (table 4).

All analyses tabulated herein were done at the U.S. Geological Survey laboratory in Salt Lake City, Utah. Most samples for bacteriological analyses cited were analyzed at the Montana Department of Health Laboratory in Helena. Five bacteriological analyses were made in the U.S. Geological Survey laboratory in Helena.

Different chemical constituents require different treatment to prevent deterioration before analysis in the laboratory. Several samples were collected at each site. A complete set of samples included four samples--one of untreated water, one of water filtered through a 0.45 micrometer membrane, one of water filtered and acidified so as to lower the pH to about 3 by the addition of double-distilled reagent-grade nitric acid, and one of water filtered and treated with mercuric chloride. Immediately after collection and treatment, the samples were chilled to about 4°C and airmailed in a refrigerated chest to the laboratory in Salt Lake City for analysis.

Samples for bacteriological analysis were collected in sterile bottles after the collection points had been disinfected by heat from a blow torch. These samples were taken to the laboratories in Helena where the analyses were begun within 4 hours.

Quality of ground water

General character of the ground water

The results of the analyses for common-found inorganic constituents (table 2) show the ground water to be a calcium bicarbonate type with the exceptions of samples from wells 10N3W16dca and 10N4W15dbb. Total hardness ranged from 100 to 520 mg/l (milligrams per liter) and averaged 229 mg/l; the water in general is considered "hard". Samples from wells 10N4W5dbb and 11N4W13dd had a dissolved-solids content greater than 500 mg/l and the average of the 18 well samples was 354 mg/l dissolved solids. Sample 10N4W15dbb, which had the highest dissolved-solids content and total hardness, 889 mg/l and 520 mg/l respectively, was a mixed ion type. The well sampled is near the edge of the study area and the constituents in the water are probably derived from a local source. Sample 10N3W16dca had an anomalously high sodium chloride content and low calcium content.

Samples from wells 10N4W23bab, 11N3W21dcc, and 11N3W30dad, and the sample from Lake Helena had iron and manganese concentrations higher than recommended limits for potable supplies. The objection to iron and manganese in excess of established limits is mainly esthetic and economic. Higher concentrations may produce reddish or brownish stains and impair the taste of the water. A possible source of metals in ground water from wells in 11N3W21dcc and 11N3W30dad and in water from Lake Helena is drainage from the Scratch-gravel Hills, where iron and manganese oxides are common in the rocks. Another possible source throughout the aquifer is solution of iron and manganese oxides that have formed coatings on the gravel and boulders in the basin-fill deposits. All other constituents analyzed were less than the limits recommended for drinking water.

Table 2.--Chemical analyses of water samples from 18 wells and two reservoirs

(Concentrations in milligrams per liter except as indicated)

Location	Depth of well or elevation of reservoir (feet)	Date of collection	Silica (SiO_2), dissolved	Iron (Fe), dissolved (ug/l)1/	Manganese (Mn), dissolved (ug/l)1/	Calcium (Ca), dissolved	Magnesium (Mg), dissolved	Sodium (Na), dissolved	Potassium (K), dissolved	Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity, total (as $CaCO_3$)	Sulfate (SO_4) dissolved
Wells													
10N3W3cab	44	8-17-71	27	10	10	48	12	15	3.2	175	0	144	64
10N3W5aba	42	8-17-71	23	10	< 1	61	12	18	2.9	217	0	178	45
10N3W6acd	48	8-18-71	22	10	< 1	62	15	21	3.1	241	0	198	58
10N3W7abb	42	8-18-71	22	10	< 1	58	15	21	3.0	244	0	200	53
10N3W11dbd	60	8-16-71	21	10	10	48	10	15	3.2	164	0	135	57
10N3W15bad	79	8-17-71	22	10	10	35	8.0	15	2.8	124	0	102	56
10N3W16dca	60	8-17-71	41	20	< 1	19	18	120	4.8	191	0	157	70
10N3W17aba	60	8-17-71	28	10	< 1	86	24	19	3.8	265	0	217	97
10N3W18adb	90	8-17-71	24	10	< 1	75	25	23	3.3	329	0	270	40
10N3W19acc	23	8-18-71	21	10	10	77	22	15	2.1	272	0	223	51
10N3W24cbd	60	8-16-71	22	10	< 1	30	6.7	12	2.9	104	0	85	48
10N4W15dbb	38	8-18-71	32	10	< 1	98	66	83	6.8	235	0	193	370
10N4W23bab	60	8-18-71	24	940	1,500	32	7.6	17	2.3	139	0	114	40
11N3W21dcc	23	8-17-71	31	50	650	63	21	24	12	298	0	244	47
11N3W30dad	52	8-18-71	17	10	60	76	25	30	3.3	298	0	244	84
11N3W32cab	—	8-18-71	23	10	< 1	67	16	15	3.2	244	0	200	59
11N3W33dac	25	8-17-71	24	10	< 1	62	12	15	3.2	213	0	175	55
11N4W13ddd	85	8-18-71	13	10	< 1	94	30	40	2.9	257	0	211	150
Reservoirs													
10N2W8caa	3800	8-16-71	19	20	< 1	30	7.8	14	3.3	100	14	105	24
11N2W19abc	3651	8-16-71	30	10	80	67	18	28	4.4	262	0	215	71

1/ Micrograms per liter.
2/ Includes nitrite.

Table 2.--Chemical analyses of water samples from 18 wells and two reservoirs--Continued

(Concentrations in milligrams per liter except as indicated)

Chloride (Cl), dissolved — 00940	Fluoride (F), dissolved	Nitrate as N2/ — 00618	Phosphate, dissolved ortho as PO_4	Phosphorus, dissolved ortho as P	Phosphorus as P, dissolved	Dissolved solids (sum of constituents)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Sodium-adsorption ratio	Specific conductance (micromhos/cm at 25°C)	pH	Temperature (°C)	Detergents (MBAS)
Wells														
2.1	0.3	1.5	0.12	0.04	0.09	264	170	26	16	0.5	386	7.7	20.5	<0.01
6.8	.2	.93	.15	.05	.10	280	200	24	16	.6	418	7.6	15.5	<.01
6.4	.2	.42	.06	.02	.05	308	220	19	17	.6	487	7.3	17.5	<.01
5.5	.2	.24	.21	.07	.08	299	210	6	18	.6	478	7.4	19.0	<.01
3.0	.3	1.5	.06	.02	.09	245	160	27	17	.5	364	7.5	15.0	<.01
2.2	.4	.61	.06	.02	.07	205	120	19	21	.6	303	7.5	14.5	<.01
120	.6	.36	.18	.06	.07	489	120	0	67	4.7	669	7.8	16.0	<.01
28	.4	.53	.09	.03	.09	419	310	96	12	.5	630	7.5	15.5	<.01
21	.2	.67	.09	.03	--	376	290	20	15	.6	605	7.6	--	--
27	<.1	.11	.15	.05	.07	350	280	60	10	.4	568	7.5	11.0	<.01
2.1	.5	.64	.12	.04	.10	178	100	17	20	.5	256	7.5	12.0	<.01
110	.2	1.6	.03	.01	.05	889	520	320	26	1.6	1,290	7.5	16.0	<.01
3.0	.3	.01	.77	.25	.26	198	110	0	24	.7	297	7.2	10.0	<.01
12	.9	.14	1.2	.38	.43	360	240	0	17	.7	550	7.4	18.0	<.01
13	<.1	1.5	.15	.05	.06	402	290	48	18	.8	625	7.4	12.0	<.01
5.9	<.1	.69	.18	.06	.07	312	230	33	12	.4	483	7.2	13.5	<.01
6.9	.3	.33	.06	.02	.07	285	200	30	14	.5	434	7.3	18.5	<.01
46	<.1	2.7	.03	.01	.02	514	360	150	19	.9	802	7.5	15.5	<.01
Reservoirs														
5.7	.7	.11	.09	.03	.07	168	110	2	22	.6	256	8.5	18.5	<.01
12	.6	.04	1.4	.44	.52	362	240	26	20	.8	520	8.3	22.0	<.01

Quality related to man's activities

Of the suite of samples collected for analyses for constituents indicative of man's activities, 64 were from private wells and 5 were from buried drains. Concentrations of all constituents in the samples analyzed were within recommended limits for drinking water. The analyses are presented in table 3; ranges and median values of the various constituents are as follows:

Constituent	Range, mg/l	Median, mg/l
Chloride, dissolved (as Cl)	1.4 - 92	9.4
Nitrate, dissolved (as N)	< .1 - 6.3	1.0
Nitrite, dissolved (as N)	< .01 - .01	< .01
Methylene blue active substance	< .01 - .02	< .01
Phosphorus, dissolved (as P)	.01 - .47	.06

Although septic-tank effluent is continuously added to the valley-fill deposits, concentrations of the constituents in the sampled ground water were relatively low. Three possible explanations of this are: 1) dilution in ground water, 2) concentration at shallow horizons in the aquifer, or 3) a combination of one and two.

Water-quality maps were prepared to show the areal distribution of nitrate and chloride (figs. 4 and 5). These maps are based on data from tables 2 and 3. If the results for samples from buried drains and the two reservoirs are excluded, nitrate ranges from less than 0.1 to 6.3 mg/l and has a median of 0.9 mg/l for 82 analyses; chloride ranges from 1.4 to 120 mg/l and has a median of 8.4 mg/l.

Table 3.--Chemical constituents that may be indicative of man's activities. Water samples from wells and drainage ditches

Location	Depth of well (feet)	Date of collection	Chloride (Cl), 00940 dissolved	Nitrite as N, dissolved	Nitrate as N, 00618 dissolved	Phosphorus as P, dissolved	Specific conductance (micromhos per cm at 25°C)	Temperature (°C)	Detergents (MBAS)
			(Concentrations in milligrams per liter)						
10N2W7baa	38	8-31-71	9.5	<0.01	1.9	0.07	398	17.0	<0.01
10N2W19aad	74	9-1-71	8.0	<.01	1.2	.09	390	14.5	<.01
10N2W29bcc	80	9-1-71	29	.01	1.8	.08	733	14.0	<.01
10N3W2bdd	40	8-31-71	3.9	<.01	2.7	.09	402	12.0	<.01
10N3W3cac	50	8-31-71	2.3	<.01	1.4	.08	372	13.5	<.01
10N3W6add	45	8-24-71	11	<.01	2.1	.02	467	--	<.01
10N3W6bcc	--	8-23-71	3.4	<.01	.1	.01	325	14.5	<.01
10N3W6caa	45	8-23-71	15	.01	.5	.01	552	18.5	<.01
10N3W6cdc	65	8-23-71	4.8	<.01	.4	.01	470	13.0	<.01
10N3W6dca	42	8-23-71	9.2	<.01	1.2	.02	477	15.0	<.01
10N3W7aaa	40	8-23-71	7.9	<.01	1.5	.02	488	13.0	<.01
10N3W7add2	40	8-24-71	10	<.01	.7	.02	507	14.0	<.01
10N3W7dbc	32	8-23-71	8.5	<.01	.2	.01	446	10.5	<.01
10N3W7ddc	65	8-24-71	26	<.01	1.9	.02	708	14.0	<.01
10N3W8adc	60	8-25-71	14	<.01	1.7	.05	612	13.5	<.01
10N3W8bba	60	8-24-71	7.1	<.01	1.1	.02	409	18.5	<.01
10N3W8cdd	52	8-24-71	19	<.01	1.8	.03	607	12.0	<.01
10N3W9dda	82	8-31-71	8.6	<.01	1.0	.07	401	11.5	<.01
10N3W11aaa	35	9-1-71	3.8	<.01	1.5	.08	361	12.5	<.01
10N3W11cca	40	8-31-71	1.8	.01	.5	.07	317	21.5	<.01
10N3W11daa	46	9-1-71	2.3	<.01	.6	.08	318	14.5	<.01
10N3W12aaa	35	8-31-71	7.8	<.01	.6	.07	315	15.5	<.01
10N3W13cdd	64	9-1-71	3.7	<.01	1.2	.06	299	15.0	<.01
10N3W14add	61	9-1-71	2.1	<.01	.6	.08	291	15.5	<.01
10N3W18ada2	41	8-24-71	24	<.01	6.3	.01	636	9.5	<.01
10N3W18baa	52	8-23-71	25	<.01	1.3	.02	708	14.5	<.01
10N3W18ccc	53	8-23-71	51	<.01	1.4	.01	1,060	20.5	<.01
10N3W18cdd	86	8-23-71	16	<.01	.4	.02	649	20.0	<.01
10N3W18dbb	40	8-23-71	11	<.01	.6	.01	528	15.5	<.01
10N3W18ddd	66	8-23-71	18	<.01	.6	.02	618	15.5	<.01
10N3W22bac	55	9-1-71	9.4	<.01	.2	.08	387	15.5	<.01
10N3W23bbb	40	9-1-71	1.4	<.01	.2	.07	235	12.0	<.01

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Table 3.--Chemical constituents that may be indicative of man's activities. Water samples from wells and drainage ditches--Continued

(Concentrations in milligrams per liter)

Location	Depth of well (feet)	Date of collection	Chloride (Cl), dissolved 00940	Nitrite as N, dissolved	Nitrate as N, dissolved 00618	Phosphorus as P, dissolved	Specific conductance (micromhos per cm at 25°C)	Temperature (°C)	Detergents (MBAS)
10N3W25bbb	60	9-1-71	4.3	<0.01	0.9	0.08	410	18.5	<0.01
10N4W1aab	76	8-30-71	11	<.01	.7	.07	393	14.0	<.01
10N4W12dad	---	8-30-71	5.9	<.01	.3	.06	485	16.0	<.01
10N4W13cbb	35	8-30-71	3.7	<.01	.1	.06	275	11.0	<.01
10N4W14bba	18	8-30-71	5.9	<.01	.1	.06	687	13.5	<.01
10N4W15baa	---	8-30-71	18	<.01	.5	.06	794	22.5	<.01
10N4W23aad	79	8-30-71	5.1	.01	.3	.06	374	15.0	<.01
10N4W23bac2	38	8-30-71	3.3	<.01	.1	.06	294	12.0	<.01
11N2W31bcb	28	8-31-71	6.6	<.01	<.1	.06	415	27.0	<.01
11N3W18dcd	---	8-30-71	16	<.01	5.0	.07	645	20.0	<.01
11N3W19dbc	45	8-25-71	11	<.01	1.7	.07	598	13.5	<.01
11N3W20ddd	BD 1/	11- -71	20	<.01	2.6	.13	704	7.0	<.01
11N3W29abb	---	8-25-71	32	<.01	2.6	.07	685	10.5	<.01
11N3W29bac	---	8-25-71	23	<.01	1.6	.05	607	11.0	<.01
11N3W29ccb	40	8-24-71	16	<.01	2.5	.05	621	15.0	<.01
11N3W30daa	10	11- -71	41	<.01	<.1	.47	1,880	9.0	.02
11N3W30dbd	57	8-24-71	17	<.01	1.5	.04	683	19.0	<.01
11N3W31ada	BD 1/	11- -71	18	<.01	1.5	.07	647	7.0	<.01
11N3W31dbc	55	8-24-71	7.0	<.01	.8	.06	593	15.5	<.01
11N3W31dcc	---	8-23-71	8.3	<.01	1.0	.02	593	11.0	<.01
11N3W31dda2	54	9-1-71	7.2	<.01	1.0	.09	556	13.0	<.01
11N3W32aaa	54	8-25-71	7.1	<.01	.9	.05	451	14.0	<.01
11N3W32acc	BD 1/	11- -71	12	<.01	2.0	.06	536	5.0	<.01
11N3W32bad	BD 1/	11- -71	16	<.01	1.5	.06	751	11.0	<.01
11N3W32bad2	BD 1/	11- -71	17	<.01	3.2	.06	614	9.0	<.01
11N3W32cac	40	8-24-71	7.2	<.01	.7	.08	474	12.0	<.01
11N3W32cbb	30	8-24-71	6.9	<.01	.9	.05	554	15.0	<.01
11N3W32ccd	40	8-24-71	8.1	<.01	1.6	.06	458	11.0	<.01
11N3W32dbb	38	8-25-71	6.0	<.01	.6	.07	463	---	<.01
11N3W33cdd	45	8-31-71	16	<.01	.3	.07	423	---	<.01
11N3W36ccd	45	8-31-71	3.0	<.01	1.0	.07	346	18.0	<.01
11N4W13ccc	93	8-25-71	17	<.01	.5	.07	882	10.0	<.01

1/ Buried drainage ditch

Table 3.--Chemical constituents that may be indicative of man's activities. Water samples from wells and drainage ditches--Continued

(Concentrations in milligrams per liter)

Location	Depth of well (feet)	Date of collection	Chloride (Cl), 00940 dissolved	Nitrite as N, dissolved	Nitrate as N, 00618 dissolved	Phosphorus as P, dissolved	Specific conductance (micromhos per cm at 25°C)	Temperature (°C)	Detergents (MBAS)
11N4W24daa	90	8-25-71	19	< 0.01	1.6	0.05	842	11.0	< 0.01
11N4W25baa	90	8-25-71	92	< .01	4.1	.01	683	13.0	< .01
11N4W25daa	60	8-25-71	19	< .01	.9	.04	511	15.5	< .01
11N4W25ddc	74	8-30-71	11	< .01	.9	.07	525	13.0	< .01
11N4W36baa	110	8-30-71	6.4	< .01	1.0	.09	379	14.0	< .01

Except for a few high values, the highest was 6.3 mg/l, the normal range of nitrate in the valley is less than 0.1 to 2.0 mg/l. The map (fig. 4) indicates that some areas in the valley have higher concentrations than other areas. The patterns of nitrate concentrations and the direction of ground-water flow (fig. 3) imply that the sources of nitrate are in the valley. Likely sources include septic-tank effluent, leachate from the landfill dump, nitrogen fertilizers, and animal wastes. Three areas of highest concentrations (centered near 10N3W17b, 10N3W5b, and 11N3W29c) coincide with more densely populated parts of the valley and could be mainly related to septic-tank effluent. The area of high concentrations centered near 10N3W17b could be related to septic-tank effluent, animal wastes, or to sewage, which was reported to have been used to float the gold dredge that operated at 10N3W18 during the 1950's. Also, this high concentration centered near 10N3W17b could be partly caused by leachate from the landfill dump (10N3W30ba). The leachate could move through the highly permeable tailings left by the gold dredge. Two other highs (centered near 10N2W7 and 10N3W2) located in agricultural parts of the valley might be related to nitrogen fertilizers. Lower concentrations along Tenmile and Prickly Pear Creeks and around the edges of the study area (recharge area) indicate that ground water moving into the valley tends to dilute nitrate concentrations and flush the nitrate down gradient.

The areas of greatest chloride concentrations (fig. 5) are directly north of Helena and centered in 11N3W29. Agricultural areas in the east-central part of the valley do not have the relatively high concentrations of chloride that they do of nitrate. This difference is probably because the only major source of chloride in the agricultural areas would be solution of the basin-fill deposits. In addition to solution of minerals, major sources of chloride include salt used on streets during the winter and septic-tank effluent. Areas of low chloride concentrations, particularly along Tenmile and Prickly Pear Creeks, probably indicate that recharge is low in chloride.

Results of bacteriological analyses

Bacteriological analyses of water from 65 wells (sampled wells indicated in table 1) were made by the Montana State Department of Health; analyses were for the coliform group by the bacteriological fermentation tube test (U.S. Public Health Service, 1962). Cased, drilled or driven wells were sampled throughout the valley. Ten of the 65 samples indicated the presence of organisms of the coliform group. Five of the 10 wells were resampled and the samples analyzed to detect the presence of fecal coliform bacteria, an indication of recent contamination of water by human or animal wastes. Results of all five analyses were negative, suggesting that the original samples may have been contaminated because of sampling techniques or because the wells were improperly sealed.

Trace elements

Trace element analyses of samples from 10 wells are presented in table 4. Concentrations of arsenic, copper, lead, and zinc approached the limits recommended by the U.S. Public Health Service for drinking water used on interstate carriers. Because of the limited number of samples, unknown natural background levels, and the many opportunities for contamination of the sample by metal from the pump or well casing, little can be concluded about the distribution of trace elements in the ground water. The analyses, however, provide background data that can be compared with future data to detect changes with time.

Table 4.--Trace elements in water samples from wells

(Concentrations in micrograms per liter)

Location	Depth of well (feet)	Date of collection	Arsenic (As), dissolved	Cadmium (Cd), dissolved	Chromium (Cr), dissolved	Cobalt (Co), dissolved	Copper (Cu), dissolved	Lead (Pb), dissolved	Mercury (Hg), dissolved	Nickel (Ni), dissolved	Zinc (Zn), dissolved	Temperature (°C)
10N2W19aad	74	9-09-71	20	<1	<1	<1	80	<1	0.3	<1	10	14.0
10N2W29bcc	80	9-10-71	<1	<1	<1	4	14	<1	.2	2	390	14.5
10N2W31aba	--	9-10-71	<1	<1	<1	<1	80	<1	.3	<1	220	15.0
10N3W11cca	40	9-09-71	<1	<1	<1	<1	290	<1	.2	4	90	15.0
10N3W12aaa	35	9-10-71	5	<1	<1	<1	530	<1	.3	2	310	15.5
10N3W24cbd	60	9-09-71	<1	<1	<1	<1	150	<1	.3	<1	70	16.0
10N3W25bbb	60	9-10-71	1	<1	<1	<1	44	<1	.3	<1	350	16.0
10N3W26ccd	44	9-09-71	<1	<1	<1	<1	54	20	.2	<1	60	17.0
11N3W31dda2	54	9-09-71	7	<1	<1	4	14	<1	.3	4	30	18.0
11N3W36ccd	45	9-10-71	6	<1	<1	<1	660	<1	.3	2	2700	14.5

Summary

With few exceptions, ground water in the Helena valley is of good quality. Despite locally high dissolved-solids content, the water is suitable for drinking according to standards recommended by the U.S. Public Health Service (1962) for drinking water used on interstate carriers. Contamination of ground water by coliform bacteria and by constituents indicative of man's activities is presently (1972) not a general problem.

The distribution of chloride and nitrate in the Helena valley is a result of at least three closely interwoven factors: source of the constituent, direction of water movement, and rate of water movement in the aquifer. The areal distribution of nitrate indicates that the sources of the nitrate are within the valley. With the exception of the two areas centered in agricultural parts of the valley, areas of highest nitrate concentrations correspond with areas of dense population.

The background data are too few to indicate whether the quality of ground water in the valley has changed with time. As long as development of the valley continues without public sewer or water facilities, it is important to monitor the water quality in order to detect problems before they become severe. It is possible that increased numbers of septic tanks, the raising of livestock within or adjacent to residential tracts, and the application of nitrogen fertilizers could result in the degradation of the quality of the ground water to a point at which a potential health hazard is created. Once that point is reached, upgrading ground-water quality may not be a simple process.

Additional data are needed to monitor and evaluate water quality in the Helena valley. These data could be obtained by:

1. Establishing a monitoring system of sampling locations selected on the basis of the nitrate and chloride distribution maps and sampling the wells at least once a year to determine if water quality degrades with time.
2. Analyzing water samples from specific depth intervals in test holes drilled especially for this purpose to determine water-quality variations with depth.
3. Studying the geology of the basin-fill deposits and hydrologic properties of the aquifer in order to better describe ground-water movement and quality.

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Glossary

Definitions of terms are derived from American Geological Institute (1962) and Lohman and others (1972).

Aquifer--Stratum or zone below the surface of the earth that contains sufficient permeable material capable of yielding significant quantities of water to wells and springs.

Evapotranspiration--A term describing that part of water returned to the air by evaporation and by transpiration of vegetation.

Hardpan--A hard impervious layer, composed chiefly of clay, cemented by relatively insoluble materials.

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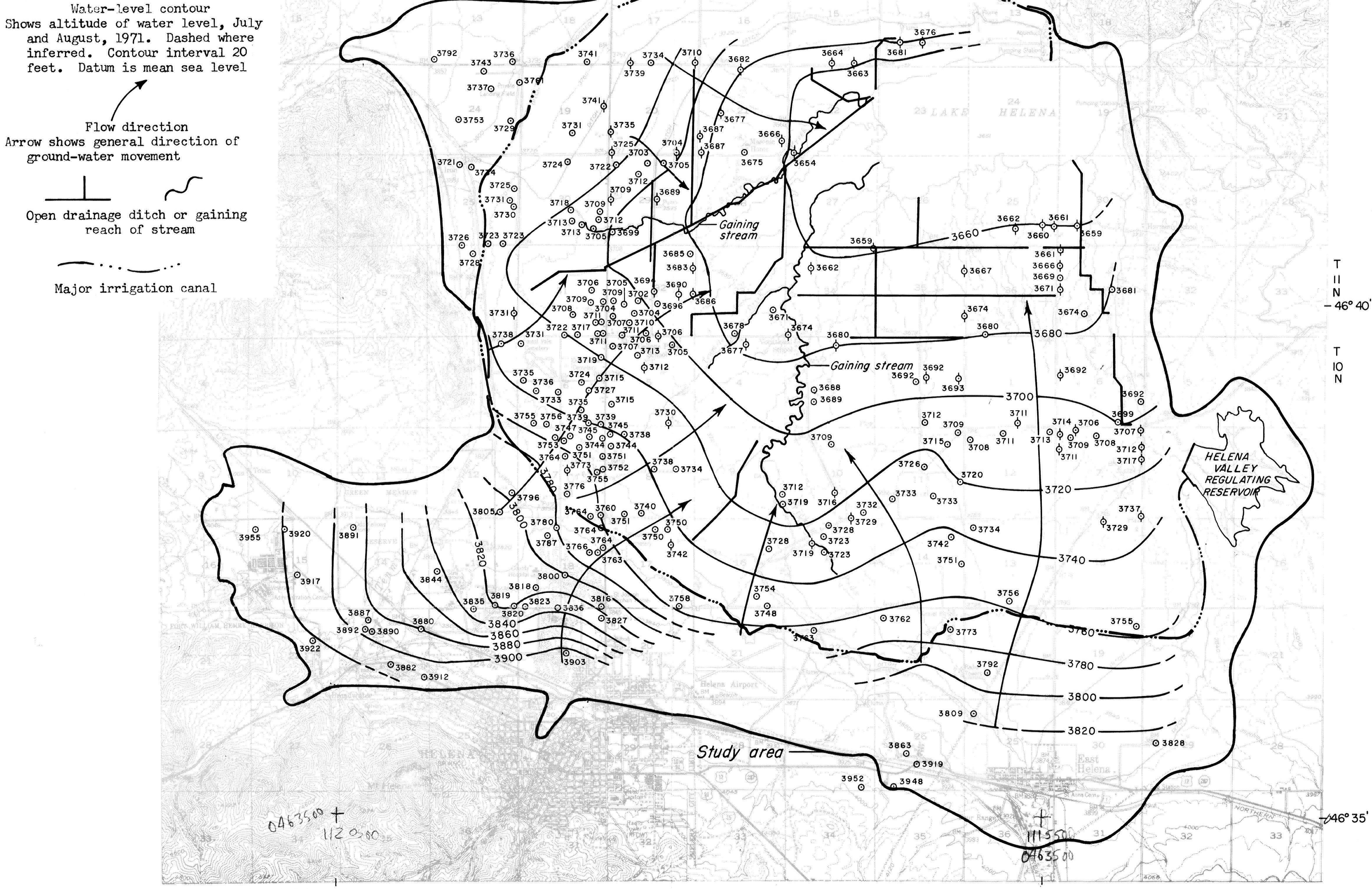

Base from U.S. Geological Survey Helena, 1950 and East Helena, 1950
Drainage ditches and irrigation canal as of 1965

112 05 00

1 1/2 0 1 2 3 MILES

Figure 3.-Water-level contours in Helena valley, Montana, July and August, 1971

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⊙ 3708 — Water-supply

ϕ 3687 — U.S. Bureau of Reclamation

Wells

Number is altitude, in feet above mean sea level, of water level, July or August, 1971

——— 3720 ——— – – –

Water-level contour

Shows altitude of water level, July and August, 1971. Dashed where inferred. Contour interval 20 feet. Datum is mean sea level

Flow direction

Arrow shows general direction of ground-water movement

Open drainage ditch or gaining reach of stream

Major irrigation canal

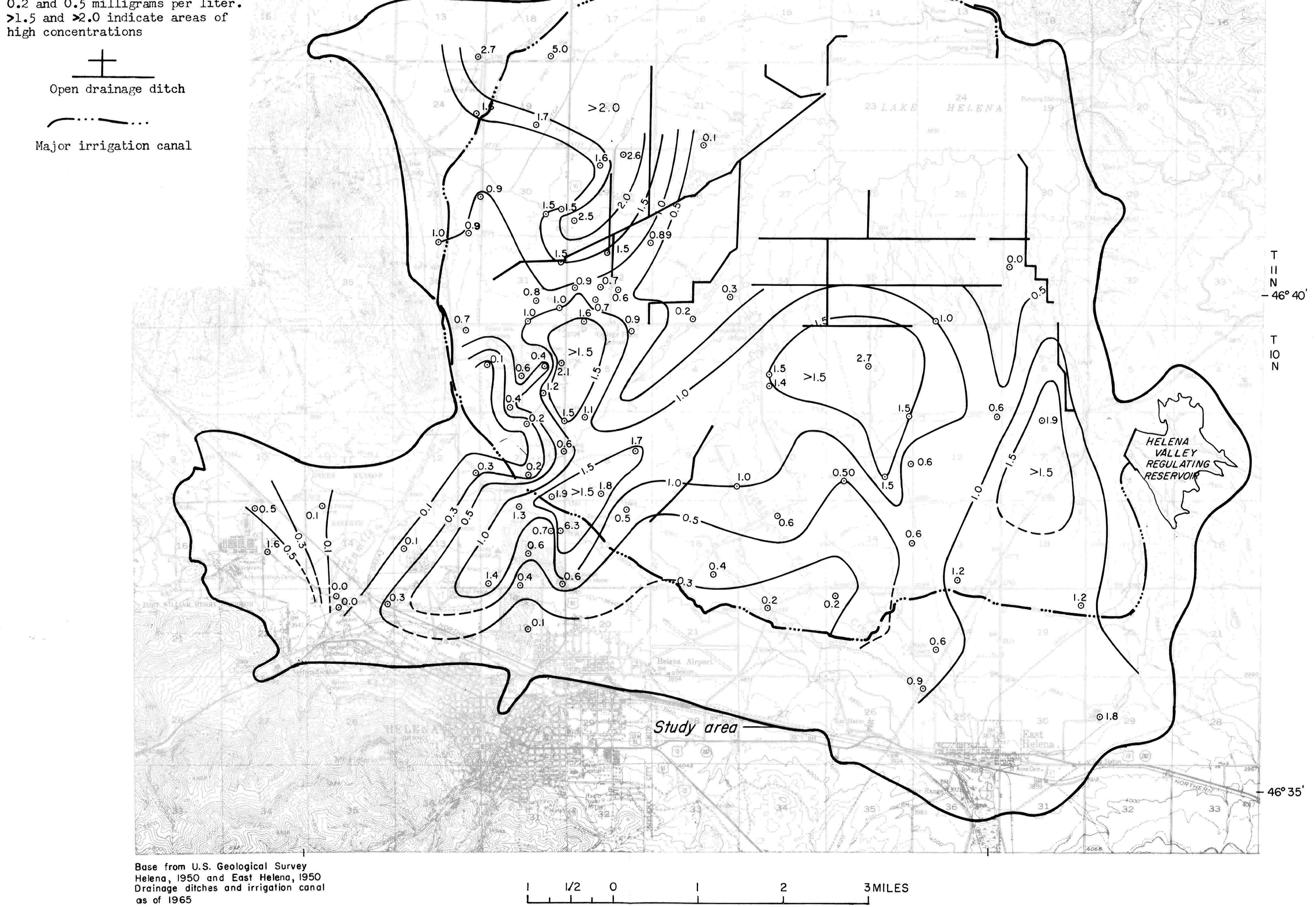

Figure 4.-Areal distribution of nitrate in ground water in Helena valley

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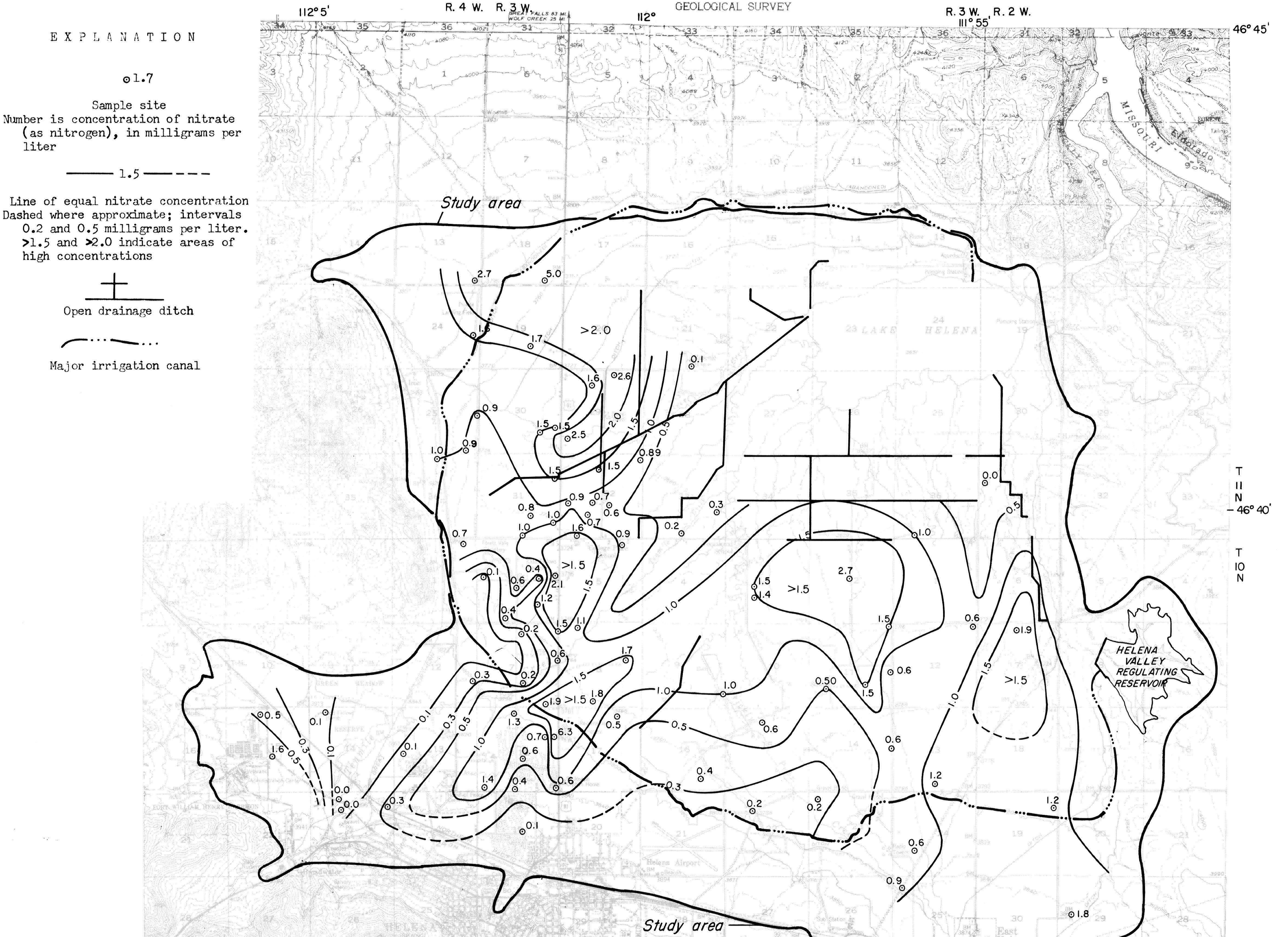

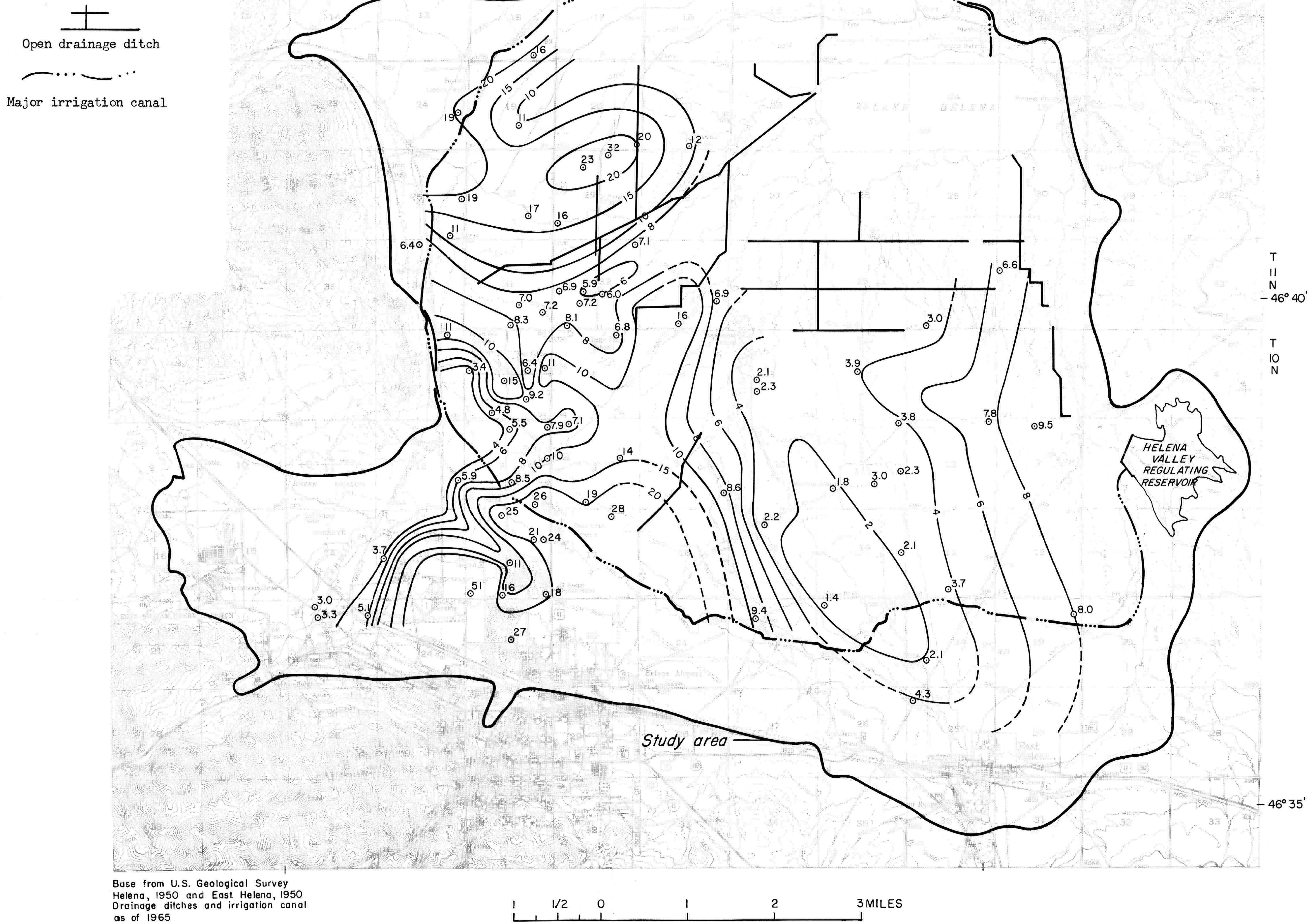

Figure 5.-Areal distribution of chloride in ground water in Helena valley

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EXPLANATION

⊙11

Sample site
Number is concentration of chloride, in milligrams per liter

——10—— — —

Line of equal chloride concentration
Dashed where approximate; intervals 2 and 5 milligrams per liter

Open drainage ditch

Major irrigation canal